GEOTEST ENGINEERING, INC.

Geotechnical Engineers & Materials Testing

5600 Bintliff Drive Houston, Texas 77036 Telephone: (713) 266-0588
Fax: (713) 266-2977

Job No. 1140200501
Trench Safety Report
December 1, 2014

Mr. William C. Rackley, P.E.
Alan Plummer Associates, Inc.
3100 Wilcrest Drive, Suite 270
Houston, Texas 77042

Reference: Trench Safety Design Considerations
Odor Control Design at 11th Street Facility
WBS No. R-000020-0010-3
Houston, Texas

Dear Mr. Rackley:

We are pleased to present our geotechnical information for trench safety for the referenced project.

For trench excavation, it is essential to maintain the stability of the sides and base and not to disturb the soil below the excavation grade. This is necessary to prevent any damage to adjacent facilities as a result of either vertical or lateral movements of the soil. In addition, a satisfactory excavation procedure must include an adequate construction dewatering system to lower and maintain the water level at least 3 feet below the lowest excavation grade or a minimum of 5 feet below prevailing level of backfill during backfilling. This will minimize the potential for softening or "boiling" of the base support soil.

Trench Stability. For trench excavation, it is essential to maintain the stability of the sides and base and not to disturb the soil below the excavation grade. This is necessary to prevent any damage to adjacent facilities as a result of either vertical or lateral movements of the soil. In addition, a satisfactory excavation procedure must include an adequate construction dewatering system to lower and maintain the water level at least 3 to 5 feet below the lowest excavation grade. This will minimize the potential for softening or "boiling" of the base support soil.

The trench excavation may be shored, laid back to a stable slope (as recommended by OSHA) or some other equivalent means used to provide safety for workers and adjacent structures. The excavating and trenching operations should be in accordance with OSHA Standards, OSHA 2207, Subpart P (latest revision).

- Excavation Shallower Than 5 Feet – Protection may not be required when excavations that are less than 5 feet deep and an examination of the ground by a competent person provides no indication of potential cave-in. When any indication of hazardous ground movement or potential cave-in is anticipated during construction, adequate. protective system should be provided for all excavation even that excavations are shallower than 5 feet.

- Excavation Deeper Than 5 Feet – Excavations that are deeper than 5 feet (regardless of the type of soil encountered) should be sloped, shored, shielded or provided with some other appropriate means of protection where workers might be exposed to moving ground or cave-ins. The slopes and shoring should be in accordance with OSHA requirements. The following items provide design criteria for trench stability.

  (i) OSHA Soil Type. Based on the soil conditions revealed by the geotechnical borings, OSHA's soil type "C" should be used for the determination of allowable maximum slope and/or the design of a shoring system. For shoring deeper than 20 feet, an engineering evaluation is required.

  (ii) Trench Support Earth Pressure. Trench support earth pressure diagram was developed based on the subsurface conditions indicated by our field and laboratory investigations. The earth pressure diagram developed for trench support is presented on Figure 1. The pressure diagram can be used for the design of temporary trench bracing. Design of trench boxes for resisting lateral earth pressures can be based on an equivalent fluid pressure of 91 pcf. The effects of any surcharge loads at the ground

surface should be added to the computed lateral earth pressures. A surcharge load, q, will typically result in a lateral load equal to 0.5q. The computation of the equivalent fluid pressure assumes that water level is at ground surface, since these conditions may exist after a heavy rain or flooding.

(iii) Bottom Stability. In braced cuts, if tight sheeting is terminated at the base of the cut, the bottom of the excavation can become unstable under certain conditions. The stability of the trench bottom is governed by the shear strength of the soils and by the differential hydrostatic head. For cuts in cohesive soils (such as lean clays) as encountered in all the borings, stability of the bottom can be evaluated in accordance with the procedure outlined on Figure 2.

Lateral Earth Pressure Diagram. The pressure diagram provided on Figure 1 can be used for the design of braced excavation.

Excavation Dewatering. Excavations for the utilities along the proposed alignment may encounter groundwater seepage depending upon groundwater conditions at the time of construction and the location and depth of excavation. For cohesive soils such as lean clay and lean clay with sand as encountered in borings, groundwater may be managed by collection in trench bottom sumps for pumped disposal. It is recommended that the contractor should verify groundwater level at the time of construction and should provide an adequate groundwater control, where required.

We appreciate this opportunity to be of service to you. If you have any questions regarding the report, or if we can be of further service to you, please call us.

Sincerely,
GEOTEST ENGINEERING, INC.
TBPE Registration No. F-410

Naresh Kolli, P.E.
Assistant Project Manager

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Copies Submitted: (4)
Enclosures: Trench Support Earth Pressure – Figure 1
Stability of Bottom for Braced Cut – Figure 2
Geotechnical Design Parameter Summary: Open-cut Excavation – Table 1
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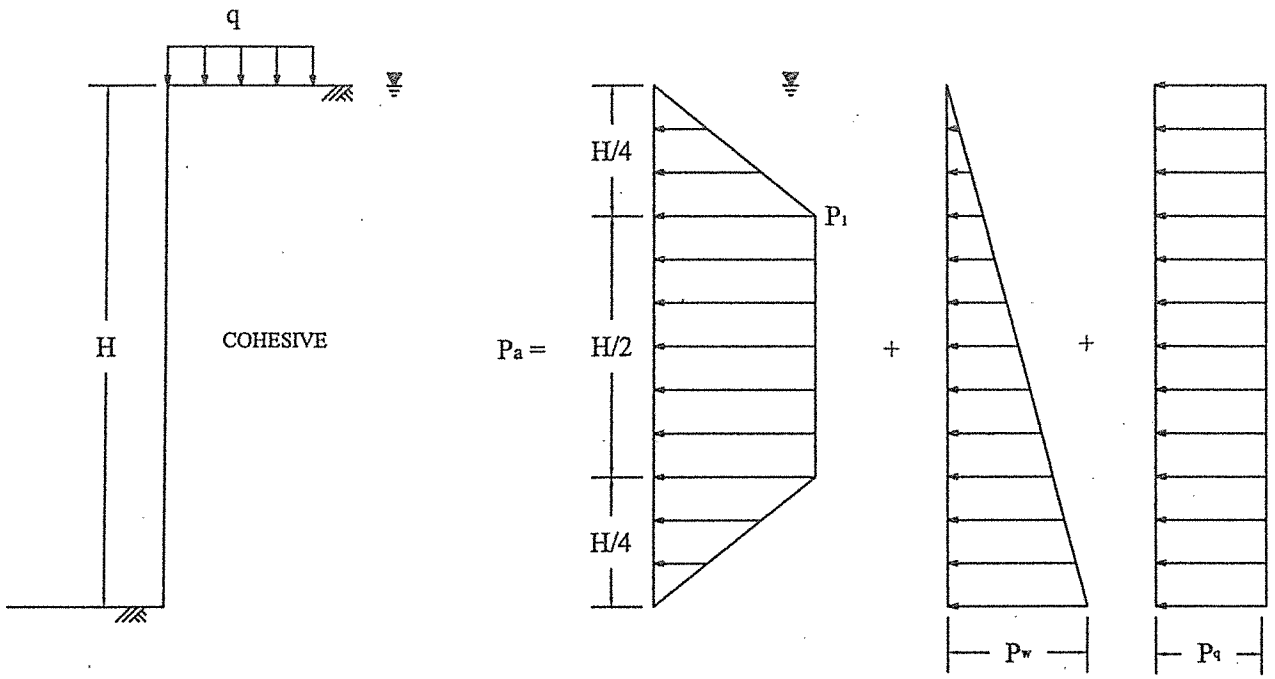

TYPICAL SOIL PARAMETERS

See Table 1 for typical values of soil parameters

BRACED WALL

For $\gamma H/c \leq 4$

$P_1 = 0.3\ \gamma_c' H$
$P_w = \gamma_w H = 62.4 H$
$P_q = 0.5\ q$

Where:

γ_c' = Submerged unit weight of cohesive soil, pcf;
γ_w = Unit weight of water, pcf;
q = Surcharge load at surface, psf;
P_a = Lateral pressure, psf;
P_1 = Active earth pressure, psf;
P_q = Horizontal pressure due to surcharge, psf;
P_w = Hydrostatic pressure due to groundwater, psf;
H = Depth of braced excavation, feet
c = Shear strength of cohesion soil, psf;

TRENCH SUPPORT EARTH PRESSURE

SUBMERGED COHESIVE SOIL

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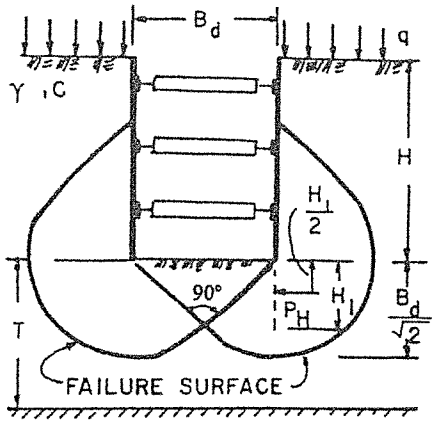
CUT IN COHESIVE SOIL,
DEPTH OF COHESIVE SOIL UNLIMITED ($T > 0.7\ B_d$)
L = LENGTH OF CUT



If sheeting terminates at base of cut:

$$\text{Safety factor, } F_S = \frac{N_C C}{\gamma H + q}$$

N_C = Bearing capacity factor, which depends on dimensions of the excavation : B_d , L and H (use N_C from graph below)

C = Undrained shear strength of clay in failure zone beneath and surrounding base of cut

γ = Wet unit weight of soil (see Table 1)

q = Surface surcharge (assumed q = 500 psf)

If safety factor is less than 1.5, sheeting or soldier piles must be carried below the base of cut to insure stability - (see note)

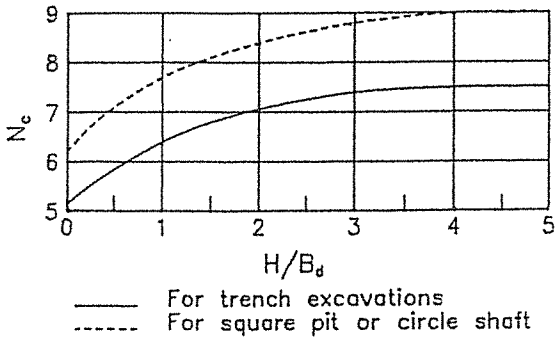
H_1 = Buried length $= \frac{B_d}{2} \geq 5$ feet

Note : If soldier piles are used, the center to center spacing should not exceed 3 times the width or diameter of soldier pile .

Force on buried length, P_H:

If $H_1 > \frac{2}{3}\frac{B_d}{\sqrt{2}}$, $P_H = 0.7\ (\gamma\ HB_d - 1.4CH - \pi CB_d)$ in lbs/ linear foot

If $H_1 < \frac{2}{3}\frac{B_d}{\sqrt{2}}$, $P_H = 1.5H_1\ (\gamma\ H - \frac{1.4CH}{B_d} - \pi C)$ in lbs/ linear foot



STABILITY OF BOTTOM
FOR
BRACED CUT

TABLE 1

GEOTECHNICAL DESIGN PARAMETER SUMMARY
OPEN-CUT EXCAVATION

Alignment	Boring Nos.	Stratigraphic Unit	Range of Depths, ft	Wet Unit Weight, γ, pcf	Submerged Unit Weight, γ', pcf	Undrained Cohesion, C, psf	Internal Friction Angle, ϕ, degree
Proposed Duct Bank	B-1 and B-2	Cohesive	0-10	120	60	1,200	--

Notes:

1. Cohesive soils include lean clay with sand.